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Ongoing Physical Activity Advice by Humans Versus Computers: The Community Health Advice by Telephone (CHAT) Trial

Abby C. King
Stanford University School of Medicine

Robert Friedman
Boston University School of Medicine

Bess Marcus
Brown University Center for Behavioral and Preventive Medicine at the Miriam Hospital

Cynthia Castro
Stanford University School of Medicine

Melissa Napolitano
Brown University Center for Behavioral and Preventive Medicine at the Miriam Hospital

David Ahn and Lawrence Baker
Stanford University School of Medicine

Purpose: Given the prevalence of physical inactivity among American adults, convenient, low-cost interventions are strongly indicated. This study determined the 6- and 12-month effectiveness of telephone interventions delivered by health educators or by an automated computer system in promoting physical activity. ***Design:*** Initially inactive men and women age 55 years and older ($N = 218$) in stable health participated. Participants were randomly assigned to human advice, automated advice, or health education control. ***Measures:*** The validated 7-day physical activity recall interview was used to estimate minutes of moderate to vigorous physical activity. Physical activity differences by experimental arm were verified on a random subsample via accelerometry. ***Results:*** Using intention-to-treat analysis, at 6 months, participants in both interventions, although not differing from one another, showed significant improvements in weekly physical activity compared with controls. These differences were generally maintained at 12 months, with both intervention arms remaining above the target of 150 min per week of moderate to vigorous physical activity on average. ***Conclusion:*** Automated telephone-linked delivery systems represent an effective alternative for delivering physical activity advice to inactive older adults.

Regular physical activity plays an important role in the prevention and control of a range of chronic health conditions (U.S. Department of Health and Human Services, 1996), but 30% or less of middle-aged and older adults engage regularly in health-enhancing physical activities (U.S. Department of Health and Human Services and National Center for Chronic Disease Prevention and Health Promotion, 2002), and 29% or more report no leisure-time physical activity at all (U.S. Department of Health and Human Services and National Center for Chronic Disease Prevention and Health Promotion, 2002). Given this, promoting regular physical activity in an efficient and cost-effective manner remains a significant clinical and public health challenge (U.S. Department of Health and Human Services, 2001; Wang et al., 2004).

The Task Force on Community Preventive Services reviewed interventions to increase regular physical activity and rated individually adapted health behavior change interventions delivered via telephone or other formats as effective and strongly recommended for broader dissemination (Kahn et al., 2002; Task Force on Community Preventive Services, 2001). In addition to freeing both participant and provider from the setting-based constraints characteristic of face-to-face approaches, the telephone has been identified, from a communication theory perspective, as the richest medium next to face-to-face communication (Webster & Trevino, 1995). This is due to its ability to allow for preexisting, “natural” elements of verbal communication as well as to allow the development of a personalized focus in a one-on-one discussion (Webster & Trevino, 1995). Such telephone counseling, based on well-established theories of behavior change, that is, social cognitive theory (Bandura, 2001) and the transtheoretical model (Marcus & Simkin, 1994), has been effective in promoting physical activity in diverse populations of initially inactive middle-aged and older adults (Castro & King, 2002; Hooker et al., 2005; King, Baumann, O’Sullivan, Wilcox, & Castro, 2002).

Abby C. King, Division of Epidemiology, Department of Health Research and Policy, and the Stanford Prevention Research Center, Department of Medicine, Stanford University School of Medicine; Robert Friedman, Boston University School of Medicine; Bess Marcus and Melissa Napolitano, Brown University Center for Behavioral and Preventive Medicine at the Miriam Hospital; Cynthia Castro and David Ahn, Stanford Prevention Research Center, Department of Medicine, Stanford University School of Medicine; Lawrence Baker, Division of Health Services Research, Department of Health Research and Policy, Stanford University School of Medicine.

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Correspondence concerning this article should be addressed to Abby C. King, Stanford Prevention Research Center, Hoover Pavilion, Room N229, 211 Quarry Road, Stanford, CA 94305-5705. E-mail: king@stanford.edu

Emerging telecommunication technologies provide one potentially effective method for delivering ongoing, individually tailored physical activity telephone advice and support to large numbers of people at potentially lower cost per person (Marcus, Nigg, Riebe, & Forsyth, 2000). Extending the reach of telecommunication technologies to promote physical activity has recently been accomplished through the development and successful evaluation of telephone-linked, interactive voice response systems for delivering physical activity advice (Jarvis, Friedman, Heeren, & Cullinane, 1997; Pinto et al., 2002). However, few automated delivery programs have been formally evaluated or compared with programs delivered by trained health professionals (Jarvis et al., 1997; Pinto et al., 2002).

The Community Health Advice by Telephone (CHAT) trial evaluated the effectiveness of telephone-based physical activity guidance and support delivered via a trained health educator or an automated system across an extended (12-month) period. Both programs were developed to optimize the natural elements of "real time" personalized verbal communication (communication theory) in combination with an emphasis on empirically supported cognitive and behavioral processes of change, for example, personal commitment, enlisting support, self-efficacy enhancement, self-monitoring (social cognitive theory, the transtheoretical model). We sought to answer the following primary question in this trial: Among underactive community-dwelling adults age 55 years and older, how effective was the automated advice system in promoting regular, moderate-intensity or more vigorous (MOD+) physical activity in the short term (i.e., 6 months) and longer term (i.e., 12 months) relative to a similar program delivered by a trained health educator or to an attention-control arm? This study also examined differences in selected perceived functioning and well-being outcomes across the three study arms, in light of the importance of such outcomes to the daily quality of life of older adults and the growing literature linking such functioning and well-being outcomes to regular physical activity (Rejeski & Mihalko, 2001).

Method

Participants and Experimental Design

The methods for the CHAT trial have been described in detail elsewhere (King, Friedman, et al., 2002) and will be described briefly here. Study eligibility criteria consisted of the following: 1) ages 55 years and older; 2) not initially engaged in more than 60 minutes per week of moderate-intensity or more vigorous physical activity over the previous 6 months; 3) free of any medical condition that would limit participation in moderate-intensity exercise; 4) body mass index (BMI) $\leq$ 40; 5) average alcohol intake $\leq$ 3 drinks per day; 6) able to speak and understand English sufficiently to provide informed consent and participate in study intervention and assessment procedures; 7) regular access to a touch-tone phone; 8) not planning to move from the area over the study period; and 9) willing to be randomized to any of the three study arms. Major recruitment strategies consisted of promotion in local media outlets, along with distribution of flyers and brochures to local health clinics, pharmacies, senior centers, and other community settings. Individuals who met initial eligibility requirements during a telephone screen underwent baseline medical and psychosocial assessment. Following stratification by gender, subjects were randomly assigned, using a computerized version of the Efron procedure (Efron, 1971), to one of three 12-month experimental arms: 1) a home-based moderate-intensity physical activity program delivered primarily via a trained telephone counselor (i.e., Human Advice arm); 2) a home-based moderate-intensity physical activity program delivered primarily via an automated, computer-controlled interactive telephone system (i.e., Automated Advice arm); or 3) a health education attention-control arm. Blinded evaluation of individuals enrolled in the three arms occurred at baseline, 6, and 12 months (i.e., all study assessment staff were blinded to participant study arm assignment). The appropriate university institutional review boards approved the study protocol.

Human advice arm. This arm consisted primarily of telephone-assisted physical activity counseling by a trained health educator (King, Haskell, Taylor, Kraemer, & DeBusk, 1991). Individuals received an initial in-person 30-40 minute health educator-led instructional session, including development of an individualized plan emphasizing a gradual progression of activity frequency, duration, and intensity towards a goal of 30 minutes or more of moderate-intensity endurance exercise (primarily brisk walking) on most days of the week (Pate et al., 1995). The remaining intervention contacts occurred via brief (i.e., 10 to 15 minutes) structured counselor-initiated telephone calls that occurred on a bi-weekly, then monthly basis. Each participant was scheduled to receive approximately 15 contacts during the study year during which they received individualized information, support, and problem-solving around physical activity barriers. Discussion of cognitive and behavioral strategies, derived from Social Cognitive Theory (Bandura, 2001) and the Transtheoretical Model, (Marcus & Simkin, 1994) occurred as appropriate to each person's stage of motivational readiness for change (Marcus & Simkin, 1994). Telephone contacts were supplemented with informational mailings and use of a Yamax Digi-walker pedometer to provide individualized activity feedback to the participant (AccuSplit, San Jose, CA) (Bassett et al., 1996). All participants in this arm recorded information about their physical activity levels (e.g., type, frequency, duration, steps accumulated on the pedometer) on a daily basis, and then reported this information to their telephone counselor during their regular telephone contacts.

Automated advice arm. This arm consisted primarily of telephone-assisted physical activity counseling by an automated telephone-linked computer (TLC) system (Pinto et al., 2002). The counseling content delivered in the TLC-based physical activity program was modeled after the counseling protocol utilized in the Human Advice arm and was similarly based on Social Cognitive Theory and the Transtheoretical Model (King, Friedman, et al., 2002). Individuals randomized to this arm received an initial in-person health educator-led instructional session that was identical to that in the Human Advice arm, with the exception of additional instructions in the use of the TLC system. The content of the counseling delivered by TLC was consistent with that delivered by the health educators, including physical activity assessment, progress evaluation, individualized problem-solving, goal-setting, feedback, and delivery of positive support and tailored advice. The total number and schedule of 'counselor'-initiated contacts by the TLC system, using a programmed out-dialer, was the same as that scheduled in the Human Advice arm. TLC 'spoke' to participants over the telephone using computer-controlled speech generation. The users communicated using the touch-tone keypad of their telephones (Jarvis et al., 1997; Pinto et al., 2002). At the beginning of each call, participants in each intervention were asked whether they had experienced any physical symptoms or complaints that could interfere with their physical activity program. Participants in both interventions responding 'yes' to this question were told to stop exercising and contact their personal physician to discuss the health issues further. This issue was assessed on the next call in both intervention arms.

Intervention quality assurance procedures for the two intervention arms included weekly evaluation of telephone counseling session number, content, and length. For the Human Advice arm, this was accomplished through review of counselor summary forms completed at the time of each contact and independent review of audio-taped telephone contacts for appropriate content (approximately one-third of telephone contacts—which were routinely audio-taped by counseling personnel after securing participant permission–were randomly selected for independent review by study investigators and non-study doctoral level clinical psychologists) (King, Friedman, et al., 2002). For the Automated Advice arm, quality control was accomplished through semi-weekly evaluation of the technical performance of the automated system via TLC's automatic contact summarization database, as well as daily monitoring of the automated system's telephone 'help' line, which was used by participants to report any problems related to interacting with the TLC system (King, Friedman, et al., 2002).

Attention-control arm. Individuals randomized to this arm were offered weekly health education classes that focused on a variety of non-physical activity topics of interest to middle- and older aged adults such as nutrition and home safety, and were asked not to change their usual physical activity patterns during the 12-month study period. At the end of 12 months, persons in this arm were offered a six-month health educator-delivered telephone-based exercise program.

Measurement of Physical Activity

Stanford 7-day physical activity recall (PAR). The 7-Day PAR (Blair et al., 1985) served as the primary measure of physical activity. The PAR provides an estimate of energy expenditure and minutes per week engaged in MOD+ activity, as defined by the most recent Compendium of Physical Activities (Ainsworth et al., 2000). The PAR is a validated and extensively used structured interview in which the participant estimates the amount of time spent each day during the past seven days in four intensity categories of activity: sleep, and moderate, hard, and very hard physical activity (Sallis et al., 1985). Inter-rater and test-retest reliabilities have been reported in the .69–.86 range (Gross, Sallis, Buono, Roby, & Nelson, 1990; Rauh, Hovell, Hofstetter, Sallis, & Gleghorn, 1992), and concurrent validity in the .75-.84 range (Dubbert, Weg, Kirchner, & Shaw, 2004). Time in light activity is derived by adding minutes spent in sleep to the total number of minutes spent in the assessed physical activity categories, then subtracting this sum from 24 hours. The PAR-based mean daily energy expenditure estimates ($kcal/kg^{-1}/day^{-1}$) from MOD+ activity was considered to be the primary study outcome measure (U.S. Department of Health and Human Services, 1996).

The PAR was supplemented with the CHAMPS physical activity questionnaire for older adults (Stewart, Mills, et al., 2001). This instrument has been found to provide a valid and reliable estimate of energy expenditure in middle- and older-aged adults (King, Baumann, et al., 2002; King, Pruitt, et al., 2000; Stewart, Mills, et al., 2001; Stewart, Verboncoeur, et al., 2001). Three-month stability coefficients have been reported to be in the .70–.84 range for the caloric expenditure measure in community samples of older adults (Harada, Chiu, King, & Stewart, 2001; Stewart, Mills, et al., 2001). The instrument has also been shown to have concurrent validity when compared with interviewer-collected physical activity data (King, Pruitt, et al., 2000; Stewart, Mills, et al., 2001), as well as sensitivity to change with a moderate-intensity physical activity program in at least six different community samples of middle-age and older women and men (Hooker et al., 2005; King, Baumann, et al., 2002; King, Pruitt, et al., 2000b; Stewart, Verboncoeur, et al., 2001). In addition to energy expenditure estimates, estimates of mean times per week engaged in 30 minutes or more of moderate intensity or more vigorous (MOD+) physical activity and mean minutes per week in MOD+ activity can also be derived from the CHAMPS (Stewart, Mills, et al., 2001). We also evaluated the sensitivity of the Yale Physical Activity Survey in the current study (DiPietro, Casperson. Ostfeld, & Nadel, 1993), but given that this instrument, in contrast to the other two instruments described above, was not found to be sensitive to change in this study, it will not be discussed further.

Objective physical activity measurement. Approximately 26% (25.7%) of study participants (n = 56) were randomly selected from across the three study arms to wear an accelerometer (CSA Actigraph, model #7164; Computer Science and Applications, Shalimar, FL; currently manufactured by Manufacturing Technologies, Inc., http://www.mtiactigraph.com) that recorded body movement continuously for up to 7 days during approximately the mid-point of the intervention (i.e., 6 months). Accelerometry provides a valid and reliable indicator of amount of physical activity, and is considered to be the most efficient and effective means of validating physical activity behavior in epidemiological and RCT research (King, Baumann, et al., 2002; King et al., 1991; Pruitt, Haskell, Bolen, Ahn, & King, 2003, Pruitt, Varady, Haskell, Bolen, & King, 2002). In order to more accurately identify moderate-intensity activity, individualized accelerometer count 'thresholds' were determined by having participants wear the accelerometer at 6 months while walking on a level treadmill at a pace required to elicit a heart rate of 65–75% of maximal predicted heart rate (Pruitt et al., 2002, 2003). These individualized activity count thresholds were subsequently applied to the accelerometry data collected in the field to determine amount of time spent in MOD+ activity.

Measurement of Perceived Functioning and Well-Being

Two perceived functioning and well-being questionnaires of particular relevance for older adults were collected at baseline, 6, and 12 months. The Vitality Plus Scale (VPS) is a 10-item questionnaire that assesses, on a 5-point scale, current well-being constructs that have been associated with regular physical activity and are relevant for older adults, including sleep quality, energy level, mood, constipation, morning stiffness, and general pain (Myers et al., 1999). Participants also completed a validated 9-item questionnaire evaluating satisfaction with body function (e.g., fitness, stamina) and appearance (Reboussin et al., 2000).

Sample Size and Statistical Analyses

Based on previous literature investigating telephone-based physical activity interventions in similarly-aged samples (Jarvis et al., 1997; King, Baumann, et al., 2002; King et al.,1991; Pinto et al., 2002), a sample size of approximately 61 participants completing the study per cell was judged to be adequate for detecting a 30 minute per week difference across 7 days as measured by the PAR in moderate-intensity or more vigorous physical activity at 90% power with 2-sided alpha set at .05 (Kraemer & Thiemann, 1987). Analysis of variance (general linear models procedure) (Spector, Goodnight, Sall, & Sarle, 1985) was used to evaluate between-arm differences at baseline. Analysis of covariance (ANCOVA) (Spector et al., 1985) was used to assess change across the initial 6-month adoption phase as well as across the entire 12-month intervention period (Marcus, Dubbert, et al., 2000). In analyzing change, main effects for arm assignment and gender along with their interactions were evaluated, with baseline levels of the dependent variables serving as covariates. Because the gender x arm interaction was non-significant in all analyses, the results from the more straightforward analyses without the interaction term are presented. Chi-square analyses were conducted at 6 and 12 months comparing the percentages of the three arms reaching the Surgeon General's recommendation of at least 150 minutes per week in MOD+ activity (U.S. Department of Health and Human Services, 1996). Alpha was set at .05 using a 2-tailed test of significance.

We incorporated intent-to-treat principles for the primary outcome of interest, i.e., physical activity measured using the PAR, whereby, for participants with missing or incomplete PAR data at both 6 and 12 months ($n = 19$), their baseline values were used and for participants missing 6-month data only ($n = 13$), the calculated mid-point between their baseline and 12-month values was used. For participants missing 12-month data only ($n = 10$), an inspection of secondary physical activity data sources occurred (i.e., 12-month CHAMPS questionnaires, logged reports of physical activity occurring during the 7-12 month intervention period that were collected as part of all exercise advisor [automated or human] interactions). If the data from these secondary sources indicated that participants were at least as active as their 6-month PAR data indicated, then the 6-month values were used (Simkin-Silverman, Wing, Boraz, & Kuller, 2003). If no secondary data were available for the participant or indicated less physical activity was occurring relative to the 6-month PAR, then baseline values were used. Eight of the 10 participants missing only 12-month data had corroborating data from secondary sources indicating physical activity levels that were similar to or greater than those reported on their 6-month PAR. For these participants, 6-month PAR values were used at 12 months. For the 2 participants without corroborating data, baseline values were used. The intent-to-treat analyses led to results that were comparable to those conducted using the available data only. The intent-to-treat analyses are reported for the PAR outcomes. For those ANCOVAs and chi-square analyses that reached statistical significance, pre-planned comparisons between arms were conducted using the least squares means procedure in SAS (Spector et al., 1985). Because this was the first study to evaluate the impact of automated telephone advice for physical activity on the secondary outcomes concerning rated function and well-being, we conducted these exploratory analyses using the available data.

Results

Subjects

A summary of participant flow and retention is shown in Figure 1. Of the 218 individuals enrolled in CHAT, 189 (86.7%) had 6- and 12-month 7-Day PAR data. These retention rates were not significantly different across the 3 study arms (Human Advice =

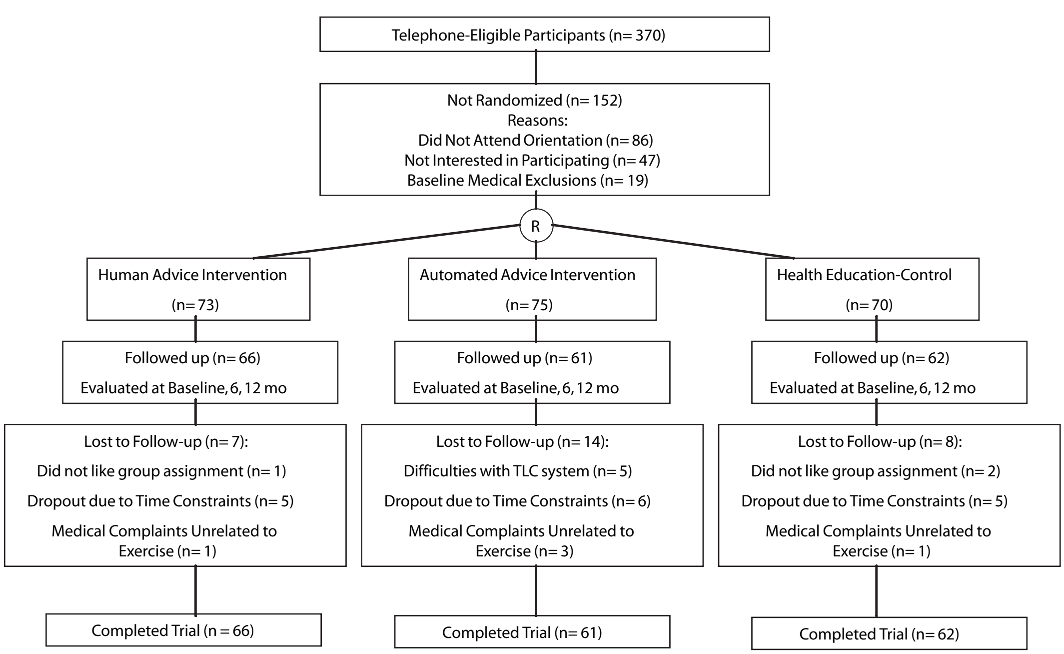

Figure 1. Participant flow.

66/73, or 90.4%; Automated Advice = 61/75, or 81.3%; Control = 62/70, or 88.6%; $p > .10$). Those with 12-month 7-Day PAR data were comparable to those without 12-month PAR data (n = 29) on the major baseline variables of interest, with the following exceptions: Those without 12-month 7-Day PAR data reported fewer baseline days per week in which they engaged in moderate-intensity or more vigorous physical activity lasting at least 30 minutes ($M = 0.59$, $SD = 1.28$ days/wk) relative to participants with 12-month data ($M = 1.23$, $SD = 1.65$ days/wk; $t(52) = 3.11$, $p = .003$); and participants without 12-month PAR data had higher rated stress scores at baseline, as measured via the Perceived Stress Scale (Cohen, Kamarch, & Mermelstein, 1983), ($M = 23.2 \pm 7.7$) relative to subjects with 12-month data ($M = 20.4$, $SD = 6.6$; $t(215) = 2.06$, $p = .04$). Descriptive baseline data by arm are shown in Tables 1 and 2 for selected variables. (Raw data are shown to allow for comparisons with other studies and to provide clinically meaningful information.) Participants were similar across the three study arms on the major baseline variables of interest (all p values $> .20$). Similar to many individuals in this age group, a large proportion of participants (Human Advice arm = 47.3%; Automated Advice arm = 59.5%; Control arm = 51.4%) were on medications for a range of chronic conditions, including hypertension, hypercholesterolemia, hyperglycemia, and asthma.

Table 3 shows the number and total duration of telephone contacts over 12 months by intervention arm. (This table includes all participants who were randomized to the two intervention arms, with the exception of those participants who dropped out of the intervention early because of initial dissatisfaction with their arm assignment [n = 1 in the Human Advice arm] or initial technical difficulties with the TLC system [$n = 5$ in the Automated Advice arm].) Although the automated system made a significantly larger mean number of total call attempts to establish contact over the 12-month period, $t(139) = 13.3$, $p < .0001$, a somewhat (though not significantly) greater number of total calls were actually completed in the Human Advice relative to the Automated Arm (see Table 3). The average call length was also greater in the Human Advice Arm relative to the Automated Arm, $t(139) = 6.3$, $p < .0001$. At the end of the 12-month intervention period, mean participant satisfaction ratings from both intervention arms were generally positive with respect to their CHAT exercise advisor (ratings of > 4 on a 6-point scale), although the overall satisfaction ratings were higher for the Human Advice arm than for the Automated Advice arm. (Human Advice mean satisfaction rating = 5.5, $SD = 0.4$ and Automated Advice mean satisfaction rating = 4.3, $SD = 1.0$; $t(43.5) = 7.1$, $p = .0001$.)

Table 1
Descriptive Statistics [Mean (Standard Deviation), Frequency] for Selected Variables at Baseline (Raw Data)

Variables	Human advice ($n = 66$)	Automated advice ($n = 61$)	Control ($n = 62$)
Age, mean (*SD*)	60.5 (6.0)	61.6 (5.9)	60.2 (4.5)
Years of education, mean (*SD*)	16.3 (1.8)	16.2 (1.8)	16.1 (2.0)
% White	81.8	93.3	87.1
% Women	70.5	69.7	67.7
% Married	69.7	68.3	56.5
% Employed	65.2	56.0	71.0
Body mass index [kg/m^2], mean (*SD*)	29.9 (5.2)	29.1 (5.1)	29.5 (5.9)
Number of medications, mean (*SD*)	2.1 (1.4)	2.1 (1.5)	1.9 (1.4)

Five participants randomized to the Automated Arm reported initial technical problems with the TLC system early in the project and soon afterwards dropped out of the study. All reported problems were fixed. Forty-one Automated Arm participants (55%) utilized the TLC telephone help line at least once during the intervention to obtain assistance with the TLC system. The questions directed to the independent staff manning the TLC help line were typically simple in content (e.g., forgotten password; system called at wrong time) and were able to be resolved by the TLC programming staff with minimal difficulty, typically within 24 hours of notification.

For the Control arm, average attendance to the weekly health education workshops equaled 5.7 sessions across the 12-month period. For the 26 subjects who attended at least one workshop, mean attendance rates across the year equaled 14.8 sessions (range = 1-50 out of 50). Participants who missed any workshop received the relevant informational materials through the mail.

Changes in Initial (6-month) Physical Activity

At 6 months, both the Human Advice and Automated Advice arms, while not significantly different from one another ($p = .73$), had significantly greater mean energy expenditure in MOD+ activity than the Control arm ($F(4, 217) = 4.73$, $p = .01$ (see Figure 2). Similarly, both the Human Advice and Automated Advice arms, while not significantly different from one another ($p = .65$), had significantly greater mean minutes/week spent in MOD+ activity than the Control arm, $F(4, 217) = 4.73$, $p = .01$. Comparable arm differences were found for the number of days per week engaged in 30 minutes or more of MOD+ activity (p values for Human Advice vs. Control = .0001; for Automated Advice vs. Control = .003) (see Table 2 for means).

The ANCOVAs using the CHAMPS data mirrored the PAR results in showing significant differences between the two physical activity arms and Controls for mean energy expenditure (kcal/kg^{-1}/day^{-1}) in MOD+ activities ($F(4, 217) = 7.73$, $p = .0006$); mean minutes per week in MOD+ activity, $F(4, 217) = 8.93$, $p = .0002$; and number of times per week engaged in 30 minutes or more of MOD+ activity, $F(4, 217) = 4.57$, $p = .01$ (see Table 2 for means).

As expected, the CHAMPS-based means were generally higher than those found with the PAR. This is because the CHAMPS questionnaire involves self-reporting of ‘usual activity levels’ over the previous 4-week period and has participants choose categories reflecting varying ranges of minutes/week engaged in each activity. In contrast, the PAR asks them to report actual minutes engaged in each activity for each day of a specified period, with the interview format providing a level of probing and clarification absent from the paper-and-pencil CHAMPS (King, Pruitt, et al., 2000). Because of these constraints, the CHAMPS and similar questionnaires are best utilized to understand *relative* differences in physical activity across individuals and/or across time as opposed to absolute physical activity levels for each individual as targeted in the PAR.

At six months, a significantly greater percentage of subjects in the Human Advice (52.7%) and Automated Advice (44.6%) arms

Table 2
Descriptive Baseline Statistics [Mean (Standard Deviation), Frequency] and Change at 6 and 12 Months for 7-Day Physical Activity Recall (PAR) and CHAMPS Variables, by Study Arm (Raw Data; for PAR, Additional Baseline-Adjusted Data Based on Intent-to-Treat Analyses)

Variables	Human advice (n = 66)	Automated advice (n = 61)	Control (n = 62)
PAR energy expenditure in moderate-intensity or more vigorous (MOD+) activity, kcal/kg^{-1}/day^{-1} (*SD*)			
Baseline:	0.85 (1.0)	0.80 (1.2)	0.95 (1.3)
6 months:	1.69 (1.1)	1.53 (1.3)	0.99 (1.1)
6 month-baseline change:	0.84 (1.3)**	0.73 (1.6)**	0.04 (1.4)
12 months:	1.64 (1.3)	1.56 (1.4)	1.21 (1.2)
12 month-baseline change:	0.79 (1.5)**	0.76 (1.8)*	0.26 (1.5)
Baseline-adjusted means (*SD*s) based on intent-to-treat analysis:			
6 months:	1.67 (1.2)**	1.60 (1.2)**	1.03 (1.2)
12 months:	1.66 (1.3)**	1.55 (1.3)*	1.10 (1.3)
PAR minutes of MOD+ activity/wk, mean (*SD*)			
Baseline:	99.7 (147.6)	78.4 (113.3)	92.2 (126.7)
6 months:	170.7 (104.4)	180.0 (230.6)	100.6 (113.8)
6 month-baseline change:	71.0 (170.8)*	101.6 (253.7)**	8.4 (144.4)
12 months:	177.8 (133.6)	157.3 (142.9)	118.4 (124.5)
12 month-baseline change:	78.1 (195.3)*	78.9 (175.6)	26.2 (151.6)
Baseline-adjusted means (*SD*s) based on intent-to-treat analysis:			
6 months:	169.1 (159.0)*	185.4 (154.1)**	111.3 (154.5)
12 months:	165.8 (136.8)*	156.3 (137.0)†	112.3 (136.8)
PAR days/wk engaged in ≥ 30 minutes of MOD+ activity, mean (*SD*)			
Baseline:	1.4 (1.5)	1.1 (1.6)	1.2 (1.4)
6 months:	3.2 (2.0)	2.6 (2.3)	1.6 (1.7)
6 month-baseline change:	1.8 (2.2)**	1.5 (2.5)**	0.4 (1.8)
12 months:	3.1 (2.0)	2.8 (2.5)	2.2 (2.0)
12 month-baseline change:	1.7 (2.4)**	1.7 (2.6)*	1.0 (2.1)
Baseline-adjusted means (*SD*s) based on intent-to-treat analysis:			
6 months:	2.9 (2.0)**	2.5 (1.9)**	1.6 (1.9)
12 months:	2.8 (2.1)**	2.6 (2.1)*	1.9 (2.1)
CHAMPS energy expenditure in MOD+ activity, kcal/kg^{-1}/day^{-1} (*SD*)			
Baseline:	1.5 (1.8)	1.4 (1.5)	1.5 (1.5)
6 month-baseline change:	2.1 (2.4)**	1.3 (2.5)*	0.5 (2.6)
12 month-baseline change:	2.1 (2.6)*	2.0 (3.0)*	0.9 (2.5)
CHAMPS minutes of MOD+ activity/wk, mean (*SD*)			
Baseline:	166.1 (210.9)	154.0 (164.0)	156.3 (152.9)
6 month-baseline change:	217.3 (252.3)**	138.5 (258.0)*	44.5 (248.3)
12 month-baseline change:	216.7 (272.2)*	205.0 (323.9)*	97.7 (252.4)
CHAMPS times/wk engaged in ≥ 30 minutes of MOD+ activity, mean (*SD*)			
Baseline:	2.5 (2.8)	3.1 (3.8)	3.1 (3.7)
6 month-baseline change:	1.4 (5.7)**	0.9 (5.7)**	−1.3 (5.3)
12 month-baseline change:	5.3 (6.1)*	4.7 (5.9)*	2.4 (4.8)

* Difference between Intervention and Control ≤ .05. ** Difference between Intervention and Control ≤ .01. † Difference between Intervention and Control = .056.

achieved 150 or more minutes per week in MOD+ activity relative to Controls (27.1%), $X^2(2) = 10.0$, $p = .007$ (Human vs. Automated Advice: $p = .41$; Human Advice vs. Control: $p = .003$; Automated Advice vs. Control: $p = .045$).

Adherence to prescribed physical activity intensity: Information assessed by the objective activity monitor. Participants randomly selected to wear the Actigraph activity monitor at 6 months wore it for an average of 5.8 days (range = 2–7 days), with similar numbers of days and hours worn per day across arms ($p > .10$). Given the reduced sample size for this substudy (n = 56), and the fact that the Human and Automated Advice arms did not differ in any of the Actigraph-derived measures (p values .28), the two arms were combined and compared to the Control arm. Intervention participants showed more physical activity relative to Controls based on the mean number of accelerometer counts accumulated per hour averaged across days worn (i.e., mean number of counts was 31.3% greater for intervention [M = 20,606, SD = 8,641 counts] versus controls [M = 15,690, SD = 6,058 counts]) ($p = .045$). In addition, the mean number of minutes spent in the individual's MOD+ activity range accumulated over 5 to 7 days was significantly greater in the two intervention arms (M = 112.5, SD = 118.3) relative to the Control arm (mean minutes = 36.8, SD = 35.2), $t(35.1) = 3.1$, $p = .004$. These data provide an objective indicator that, on the days in which the accelerometer was worn, Intervention participants engaged in greater amounts of physical activity both in general and in their targeted intensity range relative to Controls.

Table 3
Number and Length of Counselor-Initiated Telephone Attempts and Contacts Over 12 Months, by Intervention Arm

Variables	Human advice arm (n = 72)	Automated advice arm (n = 70)
Number of total call attempts to establish contact over the year, mean (*SD*)	25.0 (10.0)	50.0 (30.6)
Call attempts per completed contact, mean (*SD*)*	2.1 (1.1)	8.3 (20.7)
Minimum call attempts	1	1
Maximum call attempts	5.8	165.0
Number of calls completed, mean (*SD*)†	13.1 (2.5)	11.8 (4.8)
Minimum calls completed	4	0
Maximum calls completed	18	24
Average call length (*SD*), minutes*	10.7 (5.0)	6.6 (2.2)
Minimum call length	2	2
Maximum call length	58	20

† A call was counted as completed if physical activity was assessed. Completed calls included both counselor-initiated and participant-initiated calls. * Between-arm difference significant at $p < .00001$.

Changes in Physical Activity Across 12 Months

Twelve-month results from the 7-Day PAR for each of the three arms are shown in Figure 2. Mean energy expenditure in MOD+ activity for both the Human Advice and Automated Advice arms, while not significantly different from one another (p = .60), remained significantly greater than the Control arm, $F(4, 217) = 3.4$, $p = .036$. Similarly, mean minutes/wk in MOD+ activity for both the Human Advice and Automated Advice arms, while not significantly different from one another (p = .66), remained greater than the Control arm, $F(4, 217) = 3.14$, $p = .045$, although the results were somewhat stronger for the Human Advice arm relative to the Automated Advice arm (see Table 2). Similar arm differences were found for PAR-based number of days per week engaged in 30 minutes or more of MOD+ activity (see Table 2).

The 12-month ANCOVAs using the CHAMPS data mirrored the 7-Day PAR results in showing significant differences between the two physical activity arms and the Control arm for mean kcal/kg^{-1}/day^{-1} in MOD+ activity, $F(4, 217) = 3.66$, $p = .03$; mean minutes per week in MOD+ activity, $F(4, 217) = 3.24$, $p = .04$; and times per week engaged in 30 minutes or more of MOD+ activity, $F(4, 217) = 2.78$, $p = .05$.

At 12 months, a significantly greater percentage of subjects in the Human Advice arm (51.4%) achieved the Surgeon General's 150 or more minutes per week in MOD+ activity relative to Control (30.0%), $X^2(2) = 7.0$, $p < .03$. The Automated Advice arm (44.6%) was not significantly different from either the Human Advice arm (p = .51) or the Control arm (p = .10).

Safety of the Two Telephone-Based Physical Activity Interventions

No physical activity-related cardiac events occurred. Physical activity-related non-cardiac injuries were few and were similar in number across study arms ($p > .10$). These included mild muscular fatigue, strain, or soreness during the initial 3 - 4 months of intervention (experienced by approximately 22% [i.e., 31/141] of persons across the two physical activity arms). Such physical activity-related symptoms are typical for under-active individuals initiating a regular physical activity regimen; they were treated primarily at home and did not interfere with participation.

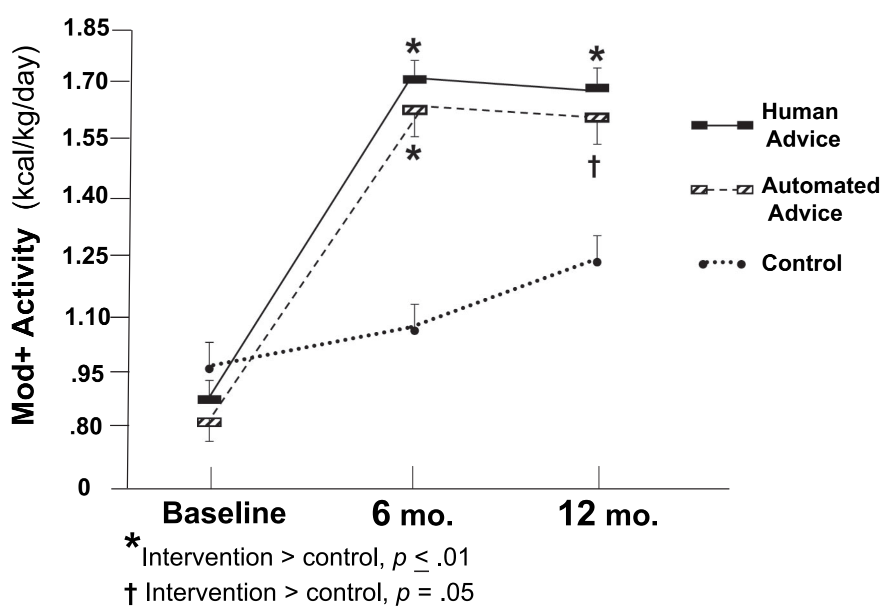

Figure 2. Mean energy expenditure (kcal/kg^{-1}/day^{-1}) in moderate-intensity or more vigorous physical activity (MOD+ activity) based on the 7-Day Physical Activity Recall (PAR) (with standard error bars), at baseline, 6, and 12 months, by study arm.

Changes in Physical Functioning and Well-Being at 6 and 12 Months

At 6 months, the three arms were not significantly different in Vitality Plus or Satisfaction with Fitness scores (p values $> .10$). At 12 months, the Human Advice arm had significantly greater improvements on both of these measures (adjusted $Ms = 37.5$, $SD = 6.1$ for Vitality Plus and 36.0, $SD = 12.3$ for Satisfaction with Fitness) relative to the Control arm (adjusted $Ms = 34.8$, $SD = 5.8$ and 30.0, $SD = 11.9$, respectively, p values $< .04$). Neither of these arms significantly differed from the Automated Advice arm at 12 months on these scales (adjusted $Ms = 35.9$, $SD = 6.3$ for Vitality Plus and 32.8, $SD = 12.1$ for Satisfaction with Fitness; $p > .19$).

Discussion

The results of this study provide the first systematic evidence that automated, telephone-based computer systems can lead to improvements in physical activity levels over an extended time period. The automated system, which was developed using established behavioral principles and strategies (Bandura, 2001; Prochaska & DiClemente, 1984), achieved significant physical activity increases in a community-based sample of middle- and older-aged adults that were comparable to those achieved by trained health educators at 6 months. By 12 months the effectiveness of the automated system appeared to diminish relative to Human Advice (i.e., mean number of minutes per week in MOD+ physical activity relative to Control was no longer significant at the .05 level with the current sample size). The mean minutes per week of MOD+ activity in the Automated Advice arm did remain, however, above the 150 minutes per week of MOD+ activity recommended by the Surgeon General and other national bodies (Pate et al., 1995; U.S. Department of Health and Human Services, 1996). The proportions of Automated Advice participants meeting or exceeding the national recommendations at 6 and 12 months compares favorably to those seen in recent physical activity trials evaluating mediated and face-to-face interventions (Marcus et al., 1998; The Writing Group for Activity Counseling Trial Research Group, 2001). However, improvements in the two rated functioning and well-being variables at 12 months were not as great in the Automated Advice as in the Human Advice Arm, suggesting that such automated systems may be less potent in influencing physical activity-related aspects of well-being that may be important to quality of life as well as continued physical activity participation (Rejeski & Mihalko, 2001).

The results expand the potential physical activity program choices available to health care providers and other community organizations. Such choices are important, given the substantial percentage of inactive individuals in this age group and the differing needs and preferences of subgroups of middle- and older-aged adults in this health area (King et al., 1997). While randomized clinical trial (RCT) research is based on evaluation of mean differences between study arms, means may conceal subgroup differences (reflected in the reasonably large standard deviations observed across the three arms at 6 and 12 months) in program response that are important to consider when making clinical or public health-based intervention decisions (King et al., 1997; U.S. Department of Health and Human Services, 2001). Systematically exploring subgroup differences in response to automated versus human-delivered programs is strongly recommended in future research, as is systematic evaluation of the relative cost-effectiveness of the two interventions when delivered in more 'real-world' settings.

Although the current study sample was largely white, well-educated, and reasonably healthy, the original automated, telephone-based system was developed and successfully tested in less-educated, lower income samples of primary care patients, 30-50% of whom were ethnic minorities (Jarvis et al., 1997; Pinto et al., 2002). The acceptability of the system among such groups in the earlier studies is encouraging, although continued exploration of its utility with a broader range of population segments is indicated. It appears, based on our results, that the use of an out-dialer that is programmed to make scheduled telephone contacts is an effective alternative to relying on participants to initiate a call into the system on a regular basis (Pinto et al., 2002).

While the one-year intervention period for this study is longer than that used in prior investigations of automated counseling systems for physical activity (Jarvis et al., 1997; Pinto et al., 2002), the question remains concerning whether the declines generally observed in the Automated Advice arm between 6 and 12 months might continue, rendering the Automated Advice program ineffective eventually in maintaining adequate physical activity levels over the long-run. This question deserves further exploration, as do methods of combining the two methods (Human and Automated advice) to yield potentially less costly yet effective long-term intervention effects.

We conclude that delivery of individualized advice and support via telephone-based automated systems is an effective and attractive option for middle- and older-aged adults that should be considered for improving regular physical activity participation. In the current study, both automated and health educator-based programs resulted in improvements in physical activity levels that have been linked to important health outcomes in aging adults (U.S. Department of Health and Human Services, 1996). Such telephone-based programs can provide a more convenient and flexible channel for delivering ongoing advice and support for the relatively large proportion of the American public who find it difficult to attend structured, setting-based classes or programs on a regular basis (King, Castro, et al., 2000; Wilcox, King, Brassington, & Ahn, 1999). Future research should focus on systematic evaluation of which subgroups of individuals should be matched to which program (human vs. automated advice vs. a combination of the two program types) to optimize sustained behavior change in a resource-efficient manner, as well expanding the exploration of automated counseling delivery systems to more diverse, underserved populations.

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